The Impact of Surface Temperature Variability on the Climate Change Response in the NH Polar Vortex

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Motivation:

The Impact of Surface Temperature Variability on the Climate Change Response in the NH Polar Vortex

or:

Does it make a difference when there is a coupled ocean?

Five pairs of experiments, control and 2xCO_2: (100 years timeslice)

Prefix (ST)	Meaning
INT	calculated INTeractively each timestep
VAR	prescribed interannually VARying monthly means
FIX	prescribed climatological FIXed monthly means

Same type for land and ocean	Different type
INTocINTIs VARocVARIs FIXocFIXIs	VARocINTIs FIXocINTIs

Model Description: IGCM-FASTOC

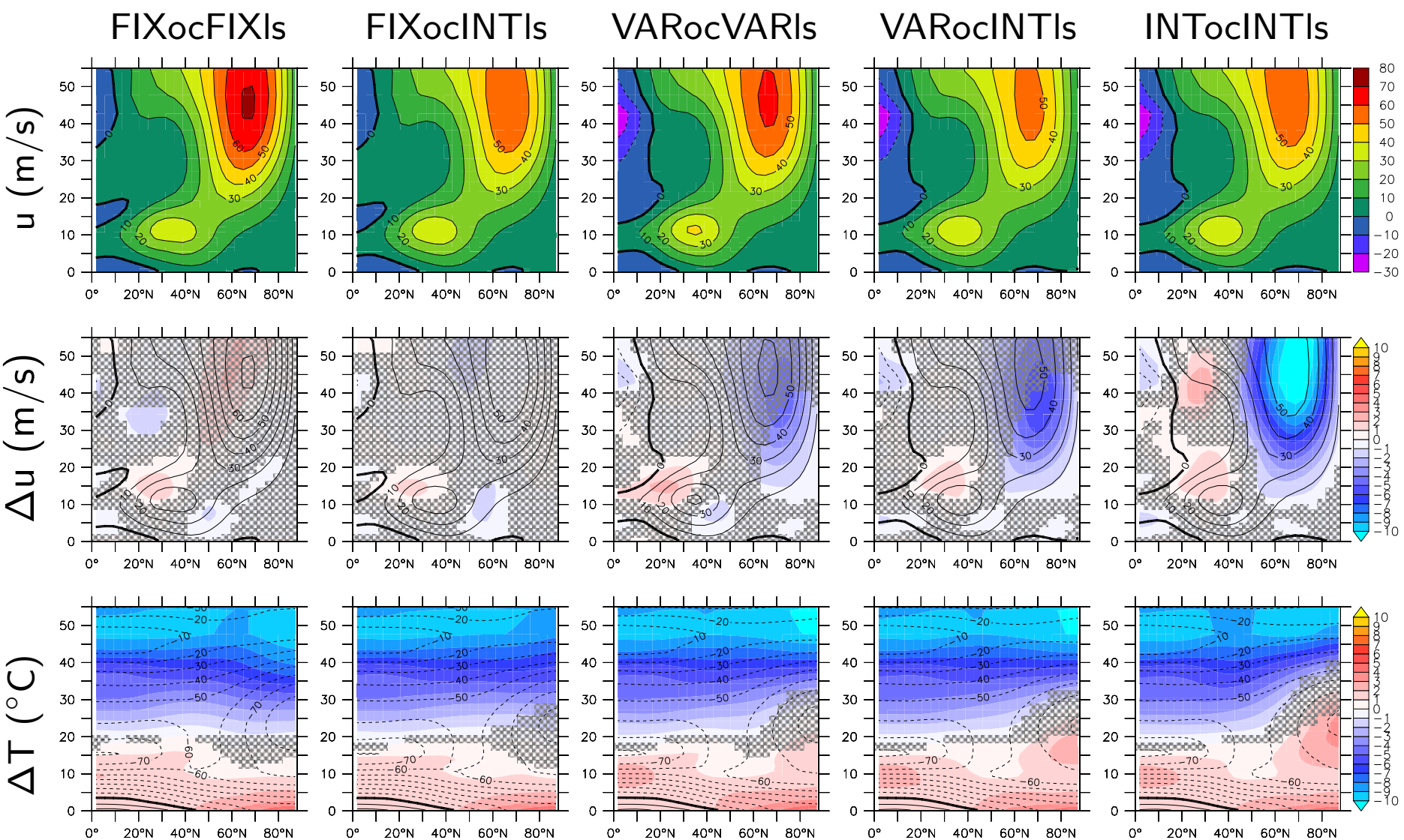
IGCM: Intermediate General Circulation Model

- Hoskins and Simmons (1975) spectral dynamical core
- T31 horizontal resolution
- 26 vertical layers (13 in stratosphere); resolution 2 km in the lower stratosphere, 4 km in the upper stratosphere; lid at 0.1 hPa.
- Betts-Miller moist/dry convection; Morcrette radiation; soil scheme.
- coupled to a 25m mixed-layer slab ocean

FASTOC: FAst STratospheric Ozone Chemistry

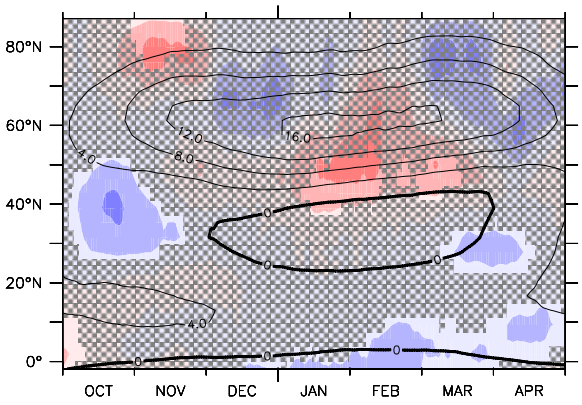
- Introduced in Bourqui et al. (2005) and Taylor and Bourqui (2005), FASTOC operates between the tropopause and the 4 hPa level.
- Chemically active species are O_x, NO_x, HO_x.
- No ozone hole; 1979 climatologies.
- CO_2 : 335.8 ppmv (for doubling: $2 \times$ Y1850 $\rightarrow$ 576 ppmv)

Control winds and CO_2 doubling response (Jan-Feb):

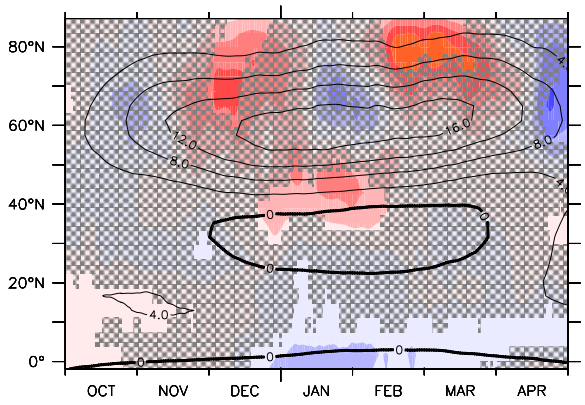


Response in 100 hPa eddy heat flux (K m/s):

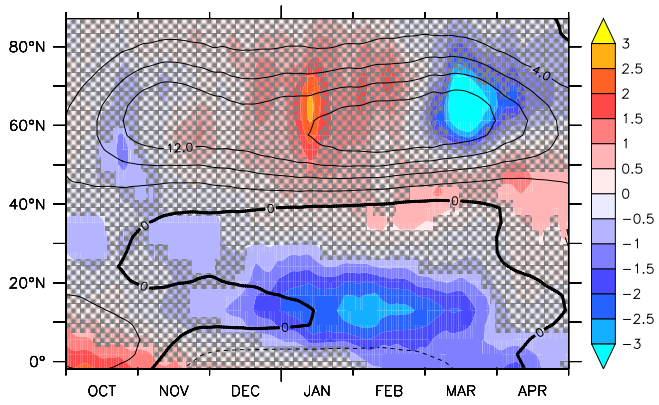
FIXocFIXIs

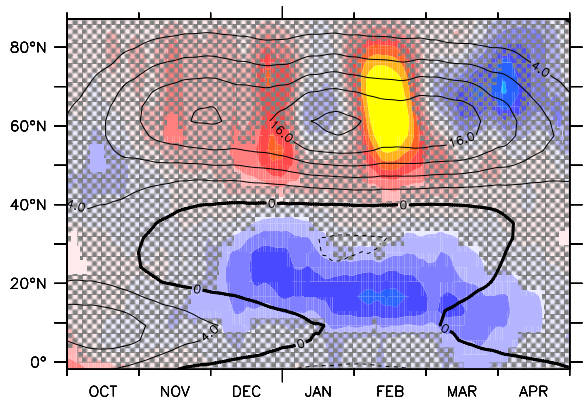


FIXocINTIs

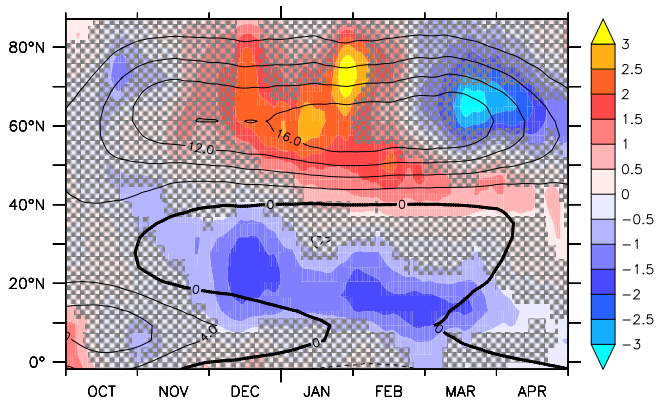


VARocVARIs



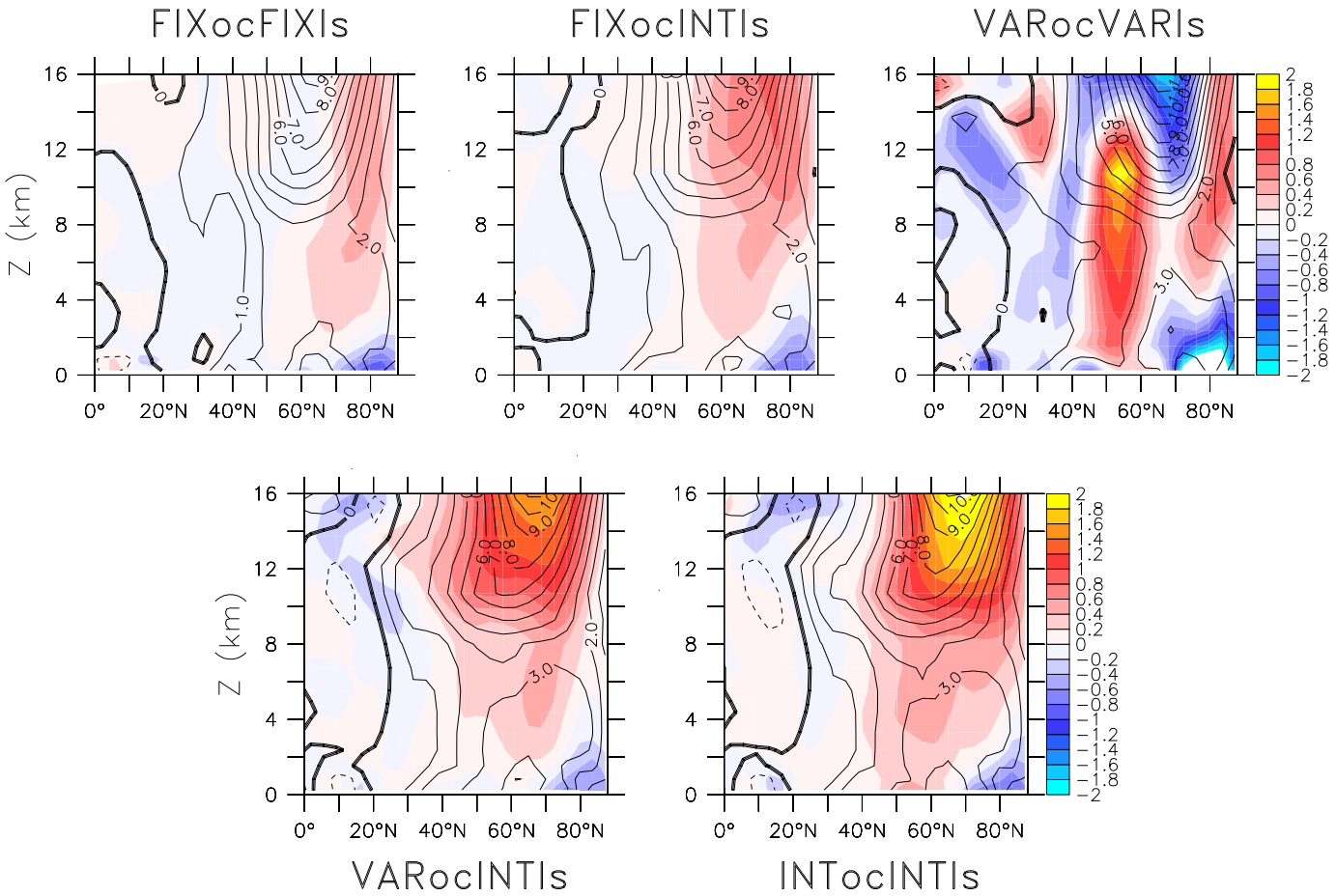


VARocINTIs



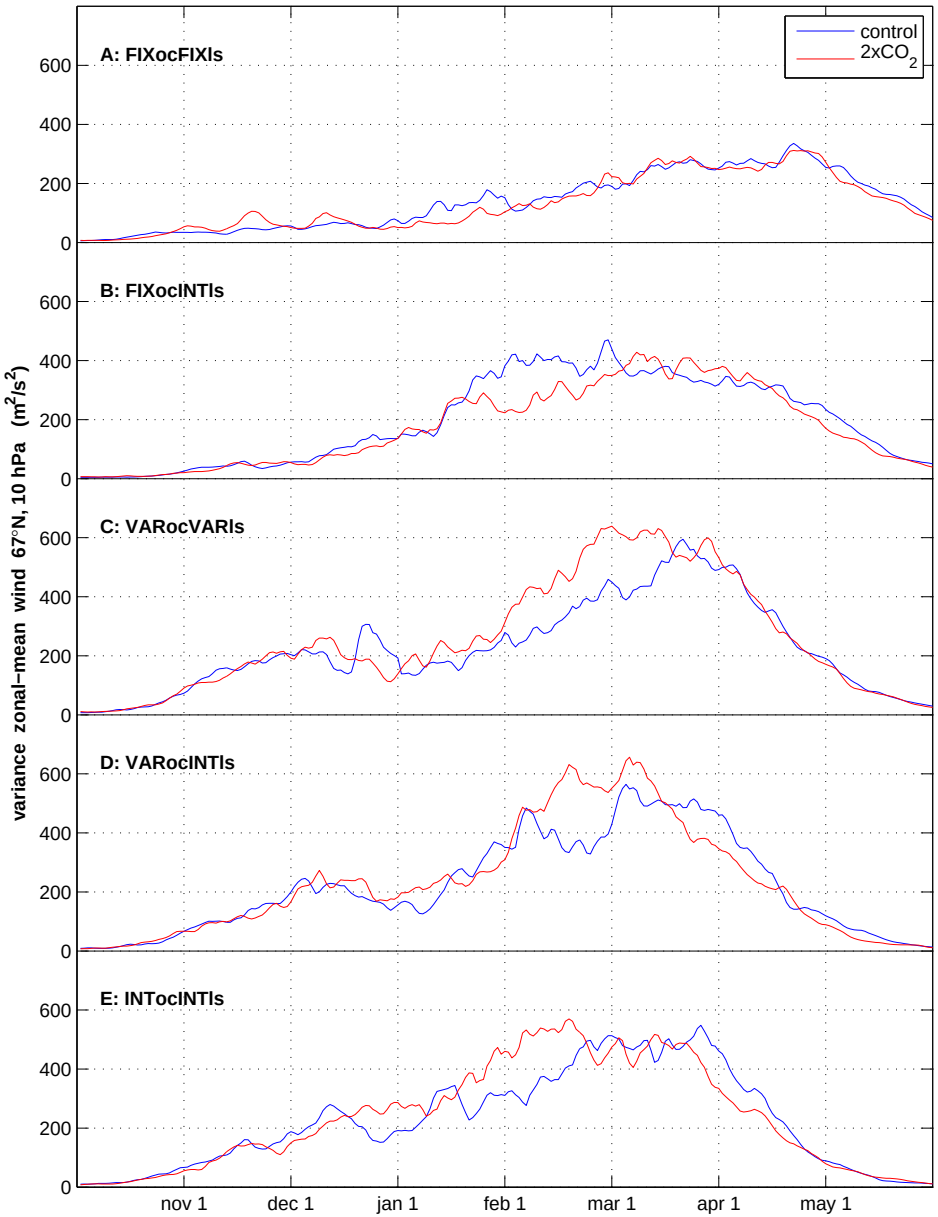
INTocINTIs

Eddy heat flux s1 component, November-December:



Vortex variability:

variances in $\overline{u}$ (m^2/s^2), 7.5hPa, 65° N

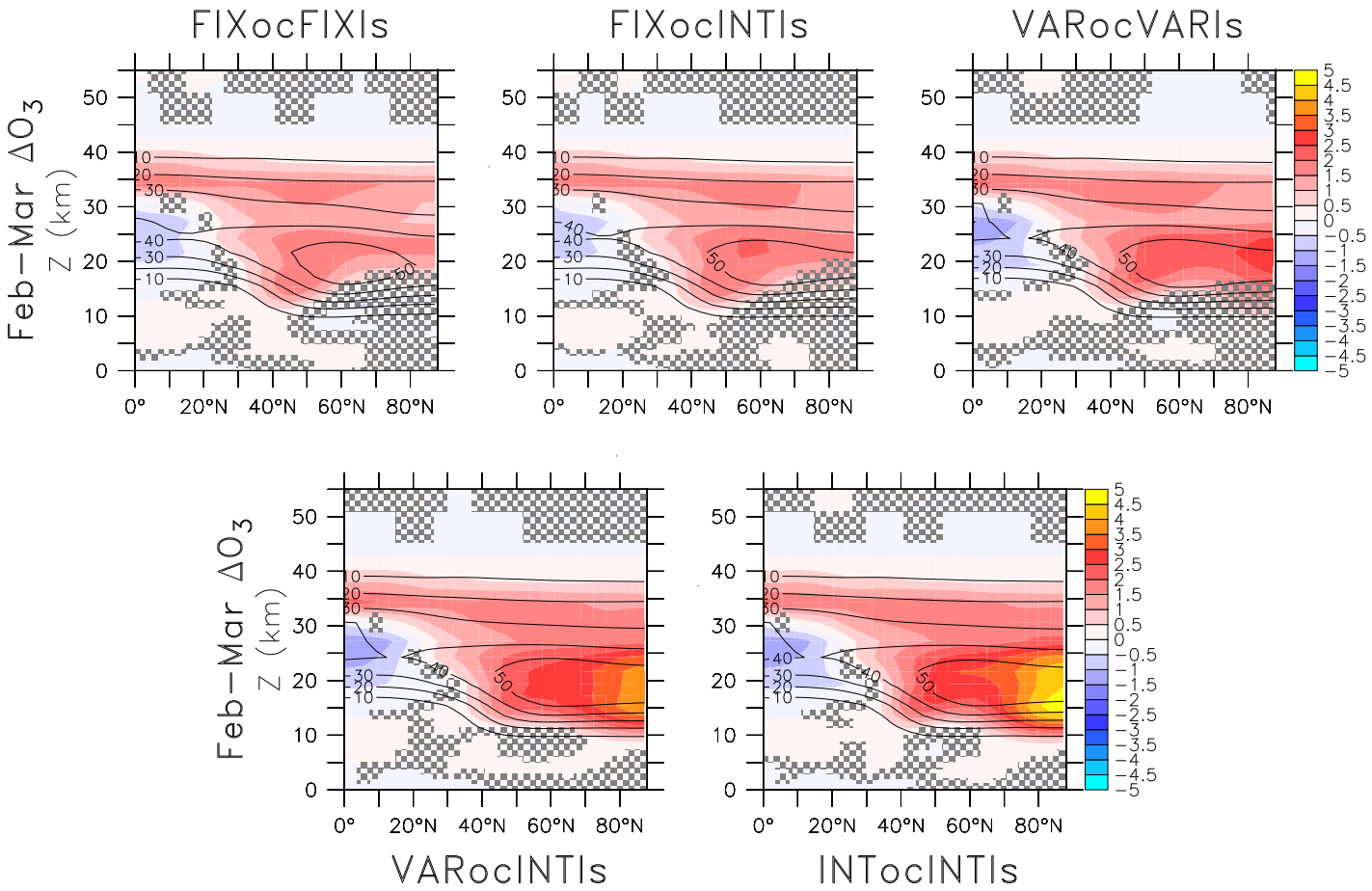


Implications for SSWs

First occurrences of $\overline{u} = 0$ at 65°N, 7.5 hPa:

	Dec-Feb		March	
	ctrl	2xCO_2	ctrl	2xCO_2
FIXocFIXIs	1	3	4	5
FIXocINTIs	17	9	11	21
VARocVARIs	20	27	26	19
VARocINTIs	26	40	35	26
INTocINTIs	29	44	43	35

Response in February-March O_3 (no. density, $10^{17}/m^3$):



Conclusions (1)

- **INTocINTIs**: A Jan-Feb warm anomaly of 3-4°C extends into the high-latitude lower stratosphere to 25 km under doubled CO_2 conditions.
- The Brewer-Dobson circulation is up to 50% stronger in high latitudes.
- Eddy heat fluxes are stronger in Dec-Jan; maximum wave forcing can occur up to 2 months earlier and during a longer time. This favours more frequent SSW events, and more multiple events per winter.

Conclusions (2)

- The strongest response to CO_2-doubling is found when land and ocean surface temperatures are both calculated interactively. A response in wavenumber-1 stationary eddies from the surface upwards is seen only in this case.

- Without daily variability, interannual variability in SSTs leads to a smaller warm anomaly lower in the polar stratosphere. There is no earlier onset of wave forcing.

- When SSTs are prescribed and climatological, there is insufficient wave forcing in the control and $2\times CO_2$ climates. The response to CO_2 doubling is mainly radiative.